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LAB-7: Optimization via Gene Expression Algorithms

CODE:

```
import numpy as np
import random

# 1. Define the Problem: Optimization Function (e.g., Sphere Function)
def optimization_function(solution):
    """Sphere Function for minimization (fitness evaluation)."""
    return sum(x**2 for x in solution)

# 2. Initialize Parameters
POPULATION_SIZE = 50  # Number of genetic sequences (solutions)
GENES = 5  # Number of genes per solution
MUTATION_RATE = 0.1  # Probability of mutation
CROSSOVER_RATE = 0.7  # Probability of crossover
GENERATIONS = 30  # Number of generations to evolve

# 3. Initialize Population
def initialize_population(pop_size, genes):
    """Generate initial population of random genetic sequences."""
    return np.random.uniform(-10, 10, (pop_size, genes))

# 4. Evaluate Fitness
def evaluate_fitness(population):
    """Evaluate the fitness of each genetic sequence."""
    fitness = [optimization_function(solution) for solution in population]
    return np.array(fitness)

# 5. Selection: Tournament Selection
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def select_parents(population, fitness, num_parents):
    """Select parents using tournament selection."""
    parents = []
    for _ in range(num_parents):
        tournament = random.sample(range(len(population)), 3)  # Randomly select 3 candidates
        best = min(tournament, key=lambda idx: fitness[idx])
        parents.append(population[best])
    return np.array(parents)

# 6. Crossover: Single-Point Crossover
def crossover(parents, crossover_rate):
    """Perform crossover between pairs of parents."""
    offspring = []
    for i in range(0, len(parents), 2):
        if i + 1 >= len(parents):
            break
        parent1, parent2 = parents[i], parents[i + 1]
        if random.random() < crossover_rate:
            point = random.randint(1, len(parent1) - 1)  # Single crossover point
            child1 = np.concatenate((parent1[:point], parent2[point:]))
            child2 = np.concatenate((parent2[:point], parent1[point:]))
        else:
            child1, child2 = parent1, parent2  # No crossover
        offspring.extend([child1, child2])
    return np.array(offspring)

# 7. Mutation
def mutate(offspring, mutation_rate):
    """Apply mutation to introduce variability."""
    for i in range(len(offspring)):
        for j in range(len(offspring[i])):
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            if random.random() < mutation_rate:
                offspring[i][j] += np.random.uniform(-1, 1)  # Random small change
    return offspring

# 8. Gene Expression: Functional Solution (No transformation needed for this case)
def gene_expression(population):
    """Translate genetic sequences into functional solutions."""
    return population  # Genetic sequences directly represent solutions here.

# 9. Main Function: Gene Expression Algorithm
def gene_expression_algorithm():
    """Implementation of Gene Expression Algorithm for optimization."""
    # Initialize population
    population = initialize_population(POPULATION_SIZE, GENES)
    best_solution = None
    best_fitness = float('inf')

    for generation in range(GENERATIONS):
        # Evaluate fitness
        fitness = evaluate_fitness(population)

        # Track the best solution
        min_fitness_idx = np.argmin(fitness)
        if fitness[min_fitness_idx] < best_fitness:
            best_fitness = fitness[min_fitness_idx]
            best_solution = population[min_fitness_idx]

        # Selection
        parents = select_parents(population, fitness, POPULATION_SIZE // 2)

        # Crossover
```

```
        offspring = crossover(parents, CROSSOVER_RATE)
        offspring = mutate(offspring, MUTATION_RATE)
        # Gene Expression
        population = gene_expression(offspring)

        # Print progress
        print(f"Generation {generation + 1}: Best Fitness = {best_fitness}")

    # Output the best solution
    print("\nBest Solution Found:")
    print(f"Position: {best_solution}, Fitness: {best_fitness}")

if __name__ == "__main__":
    gene_expression_algorithm()
```

OUTPUT:

```
Generation 1: Best Fitness = 55.82997756903893
Generation 2: Best Fitness = 26.410565738143625
Generation 3: Best Fitness = 21.857647823851615
Generation 4: Best Fitness = 20.016914182036285
Generation 5: Best Fitness = 20.016914182036285
Generation 6: Best Fitness = 20.016914182036285
Generation 7: Best Fitness = 13.81760087982789
Generation 8: Best Fitness = 13.81760087982789
Generation 9: Best Fitness = 12.077725051361178
Generation 10: Best Fitness = 10.461698723345474
Generation 11: Best Fitness = 8.933105023570093
Generation 12: Best Fitness = 6.619449963941974
Generation 13: Best Fitness = 3.1567413435369454
Generation 14: Best Fitness = 3.1567413435369454
Generation 15: Best Fitness = 3.1567413435369454
Generation 16: Best Fitness = 2.74585545305795
Generation 17: Best Fitness = 2.7031453676198964
Generation 18: Best Fitness = 2.078188177116774
Generation 19: Best Fitness = 1.5193087227027497
Generation 20: Best Fitness = 1.4413606561895607
Generation 21: Best Fitness = 0.8501569187378994
Generation 22: Best Fitness = 0.4209372164676112
Generation 23: Best Fitness = 0.3893761873774093
Generation 24: Best Fitness = 0.3893761873774093
Generation 25: Best Fitness = 0.3893761873774093
Generation 26: Best Fitness = 0.3741053651316379
Generation 27: Best Fitness = 0.1381555631914642
Generation 28: Best Fitness = 0.12238160343023853
Generation 29: Best Fitness = 0.12238160343023853
Generation 30: Best Fitness = 0.12238160343023853

Best Solution Found:
Position: [-0.03614343 -0.00257499  0.02260677  0.31412563  0.14792784], Fitness: 0.12238160343023853
```